WINTER DIET AND HABITAT SELECTION OF MARTEN IN YOSEMITE NATIONAL PARK

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Abstract: Food habits and habitat selection of marten (*Martes americana*) were studied over two winters in Yosemite National Park, California. Analysis of 91 droppings showed substantial differences in diet between the two winters. White-tailed jack rabbits (*Lepus townsendii*) and voles (*Microtus* spp.) were the principal food items in 1976–77 and 1979–80, respectively. Habitat use was determined from following 34.8 km of marten tracks. Travel routes occurred in all habitat types, but marten did not rest or hunt in meadows or on granite domes. Marten selected dense cover less than 3 m above snow level and used tree trunks and other objects for access to the subnivean zone. Logs served as den sites and hunting areas, and rocks were used for scent and urine marking. Mixed-aged forests were important in furnishing subnivean access and protective cover over a wide range of snow conditions.

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Marten are associated primarily with old-growth coniferous forests and are susceptible to alterations in their habitat (Yeager 1950, Mech and Rogers 1977, Campbell 1979, Soutiere 1979). The design of silvicultural prescriptions to accommodate this species requires the identification of the components of mature coniferous forests essential for marten habitat. The objectives of this study were to determine food habits and habitat requirements during winter, when marten appear most dependent upon mature forests.

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STUDY AREA

The 12-km^2 study area was in the Tuolumne Meadows–Lyell Canyon area of Yosemite National Park at elevations of 2,620 to 3,375 m. The dominant cover is lodgepole pine (*Pinus contorta*). Western juniper (*Juniperus occidentalis*) occurs with lodgepole pine on southern and western exposures, and mountain hemlock (*Tsuga mertensiana*) occurs between 2,800 and 2,900 m on north-facing slopes. Typical understory plants include gooseberry (*Ribes* spp.), Coville's lupine (*Lupinus covillei*), groundsel (*Senecio* spp.), and bluegrass (*Poa* spp). Interspersed with the lodgepole pine forests are 0.5- to 100-ha subalpine meadows. Granitic domes are a prominent topographical feature. The study was conducted from December through March 1976–77 and 1979–80.

Pronounced differences in precipitation and snowpack occurred between the two winters. Tuolumne Meadows had 195 cm of snowfall in 1976–77 and the snowpack was 59% of normal, compared to 662 cm and 389% of normal in 1979–80. Snow density (percent water) was considerably

greater during 1979–80 (unpubl. data, Calif. Dep. Water Resour.). Temperatures were similar for both winters, ranging from 13 to −26 C in 1976–77 and from 10 to −25 C in 1979–80.

METHODS

Forty scats were collected in 1976–77, approximately two-thirds at three latrines and the remainder along marten travel routes. In 1979–80, 51 scats were collected while following marten tracks.

The volume of air-dried scats was measured by water displacement. After rinsing to remove detritus, each scat was floated in water, and the percentage of total volume of each food item was visually estimated. Accuracy of visual estimations was within ±5% when tested against a grid counting method. Diet diversity was computed (Shannon 1948) and compared between winters using a *t* test (Hutcheson 1970).

Marten habitat use was identified by following fresh marten tracks primarily during the winter of 1979–80. Marten tracks were followed in the direction of travel, and all activities that could be ascertained were recorded.

Habitat variables were measured at travel, pause, and control points. Travel points were specific track prints obtained by following marten tracks for a random number of minutes (1–59) and then counting forward a random number of individual track prints at that time (Hargis 1981). Pause points were a random sample of points where martens engaged in some activity (e.g., entering the subnivean zone, resting, or feeding). Control points were at random distances from six north–south lines spaced 500 m apart transecting all habitat types, with the location of the first line established randomly (Hargis 1981).

Table 1. Occurrence and volume of food items in marten scats collected in Yosemite National Park during two winters.

Food item	Occurrence (%)		Volume (%)	
	1976–77 (*N* = 40)	1979–80 (*N* = 51)	1976–77 (*N* = 40)	1979–80 (*N* = 51)
Microtus	7	53	6	38
Tamiasciurus	30	33	17	26
Lepus	40		29	
Tamias	18		6	
Peromyscus	5	12	1	6
Sorex	8		2	
Scapanus	2	2	1	5
Glaucomys	2	6	tr[a]	5
Thomomys	2		tr	
Odocoileus	5	2	tr	tr
Marmota	5	6	1	1
Spermophilus	2		tr	
Martes	28	2	2	tr
Unidentified birds	30	22	7	4
Unidentified fishes	13		1	
Unidentified insects	25	8	tr	tr
Unidentifiable animal materials	10	4	1	tr
Nuts and seeds	23	16	2	1
Fungus	2		3	
Juniper berries		14		5
Debris and vegetation	63	27	6	1
Human foods	20	18	8	8
Unidentifiable matter	15	4	6	tr
Total volume, ml			95.8	79.8

[a] Trace amount.

Habitat variables, measured within a 10-m radius circle around each point, included major habitat type (forest, meadow, ecotone, dome, stream) and microhabitats; such as distances to the nearest log, rock, live tree (>1 cm dbh), and snag (dead tree >1 cm dbh); diameter of the nearest live tree and snag; percentage of overhead cover; height of first cover above snow level; snow depth; and number, diameter, and basal area of all live trees. Percent overhead cover was calculated from its presence or absence in an ocular

tube (James and Shugart 1970) held over the random track print or pause point and over four points evenly spaced 0.5 m from the track or point.

Microhabitat variables at travel and pause points were measured at the existing snow level. Variables at control points were measured at alternating high and low snow depths to ensure that the range in snow depths at control points was approximately equal to those encountered by marten during the study period.

Travel and pause points of marten were compared with control points to test the null hypothesis that marten selected habitat characteristics in proportion to their availability. Each habitat variable was tested independently, using chi-square or student's *t* tests, depending on whether the assumption of normality was met. The preference index of Strauss (1979) was used to further examine habitat use relative to availability. Habitat differences between travel and pause points and control points were tested by discriminant-function analysis to identify the key variables (Klecka 1975). All variables were entered initially into the analysis, and nonsignificant variables were eliminated by minimum Wilk's lambda. Remaining variables were considered important to marten winter habitat if univariate F ratios were significant.

RESULTS

Food Habits

White-tailed jack rabbits were the prevalent food in 1976–77, occurring in 40% of the scats and accounting for 29% of the total volume (Table 1). Direct observations and tracking showed that much of the jack rabbit was obtained from a road kill in early December. Voles were the dominant prey in 1979–80, occurring in 53% of the scats and accounting for 38% of the total volume. Tracking showed that at least two voles were captured by using lodgepole saplings for access to the subnivean zone. Douglas' squirrels (*Tamiasciurus douglasii*) occurred in approximately one-third of the scats during both winters. Pocket gopher (*Thomomys* spp.) did not occur in the 1979–80 scats, but two kills were associated with marten tracks that winter. Bird remains were present in 30% of the 1976–77 scats and 22% of the scats from 1979–80, but accounted for only a small percentage of the total volume.

Juniper berries were acquired by marten foraging in juniper trees, but pine nuts, seeds, and a fungus (*Rhizopogon* sp.) may have been acquired from squirrel caches. However, *M. martes* has been noted to dig *Rhizopogon* from the soil during early winter (Pulliainen 1981*a*). Human food was obtained from dumpsters and food scraps left by skiers. In 1979–80, bait placed in live traps for small mammals was also taken.

The diet of marten was significantly more ($P < 0.01$) diverse in 1976–77 than in 1979–80. Jack rabbits, chipmunks (*Tamias* spp.), shrews (*Sorex* spp.), ground squirrels (*Spermophilus* spp.), and fish were evident only during 1976–77, whereas juniper berries were the only food item in 1979–80 not occurring in the previous winter.

Habitat Selection

Between 26 December 1979 and 19 March 1980, 34.8 km of tracks were followed in 19 track segments (Fig. 1). Track distances ranged from 0.5 to 4.4 km ($\bar{x}$ = 1.8, SD = 1.3). Marten traveled in all major habitat types, without any detectable habitat preferences ($P > 0.05$). Pauses occurred only in forests, ecotones, and on frozen streams.

Marten traveled across ≤50-m-wide

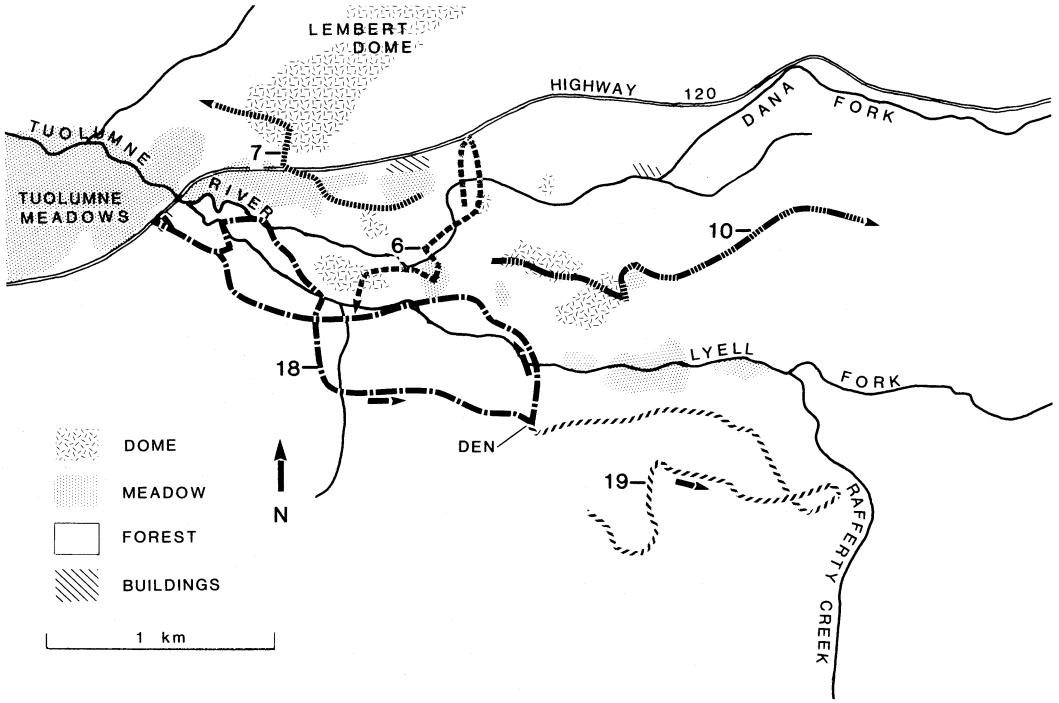

Fig. 1. Representative sample (5 of 19) of marten track segments followed during winter 1979–80 in Yosemite National Park. Track 6: 16 January 1980; Track 7: 20 January 1980; Track 10: 30 January 1980; Track 18: 12 March 1980; Track 19: 19 March 1980.

meadows but did not rest or hunt in them. Meadows >50 m were crossed using the cover of scattered trees. The longest open distance crossed was 135 m. Marten also crossed granite domes, but usually under the canopy of scattered trees.

Microhabitat structure differed ($P < 0.01$) among travel, pause, and control points, with the greatest separation between control and pause points (Table 2). Distinguishing variables were distance to the nearest tree, percentage of overhead cover, and height of overhead cover. Marten avoided areas lacking cover and preferred areas with 100% cover, especially when pausing (χ^2, $P < 0.01$). The use of partial cover was proportional to availability, at both travel and pause points (Fig. 2).

Marten preferred areas with overhead cover <3 m above the snow, both when traveling and pausing (χ^2, $P < 0.01$) (Fig. 3). At cover heights >3 m, use was proportional to availability.

Although marten showed a preference for areas with low overhead cover, they were not selective for dense forest stands. Neither basal area nor number of trees differed ($P > 0.05$) among travel, pause, and control points. Marten selected cover by traveling in a zigzag pattern from one tree to the next. As a result, two-thirds of the travel points occurred less than 2 m from a tree. This distance was less (χ^2, $P < 0.01$) than that for control points.

Marten paused at a minimum of 300 trees ranging from 1 to 102 cm in diameter and showed no preference for a par-

Table 2. Discriminant function analysis of microhabitat variables used by marten for traveling and other behavior.

	Control vs. travel	Control vs. pause	Control vs. travel/pause[a]
Key variables	Branch height, overhead cover (%) distance to nearest tree	Distance to nearest tree, branch height, overhead cover (%)	Branch height, distance to nearest tree, overhead cover
R^2	0.18	0.26	0.18
P	<0.01	<0.01	<0.01
Percent cases correctly classified	63.9	66.1	66.3

[a] Travel and pause points pooled.

ticular size class. Five of the seven kills found during 1979–80 were at tree trunks that marten had used for subnivean access. Marten also paused to rest, and perhaps groom, under trees. Most of the activity near trees occurred at ground or snow level, but marten climbed trees in eight instances. No preference was shown for snags, but snags were investigated in the same manner as live trees.

Logs and rocks were not distinguishing variables in discriminant-function analysis, but both appeared to be important habitat components based on marten behavior. Martens scent-marked small, snow-free rocks and urinated on top of rocks covered by snow. At all snow depths observed (1–350 cm), some logs remained partially exposed above the snow surface and provided marten with access to the ground. Two of the three den sites were logs. The third den, used in 1977, was in a woodpile in the basement of an occupied building.

The presence of other animals influenced marten travel patterns; marten frequently altered their course to investigate animal tracks. In addition, marten sometimes followed the tracks of Douglas' squirrels, white-tailed jack rabbits, badgers (*Taxidea taxus*), and other marten.

DISCUSSION

Differences in food habits between the two winters were partially attributable to white-tailed jack rabbits, which were the most frequent item in 1976–77, but completely absent in 1979–80. Fifteen of the 16 scats containing jack rabbit in 1976–77 were collected at latrines near a road kill, and all may have been derived from this single source. However, marten followed tracks and investigated resting areas of jack rabbits.

When latrine scats were excluded, there still were differences between the two winters. Voles, the dominant prey in 1979–80, occurred in only 13% of non-latrine scats in 1976–77. Douglas' squirrels replaced jack rabbits as the chief prey for 1976–77, occurring in 40% of the non-latrine scats and representing 40% of the volume.

The infrequent occurrence of voles in the diet in 1976–77 may be attributed to low population levels during 2 years of drought. Weckwerth and Hawley (1962) observed a direct relationship between the abundance of *Microtus* and the occurrence of *Microtus* in marten droppings. Drought conditions may have also contributed to the greater diversity of diet

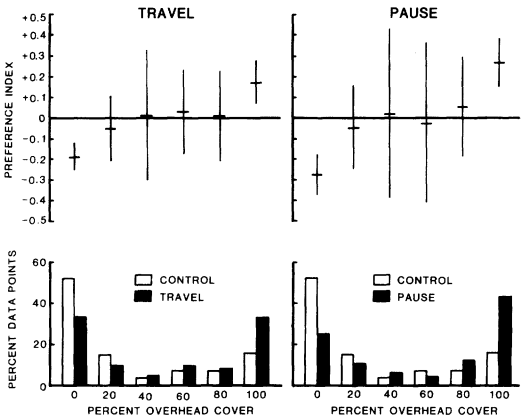

Fig. 2. Marten preference for overhead cover at travel and pause points. Above: preference index = relative use minus relative availability. Vertical bars represent 95% confidence intervals. Below: frequency within each class of overhead cover.

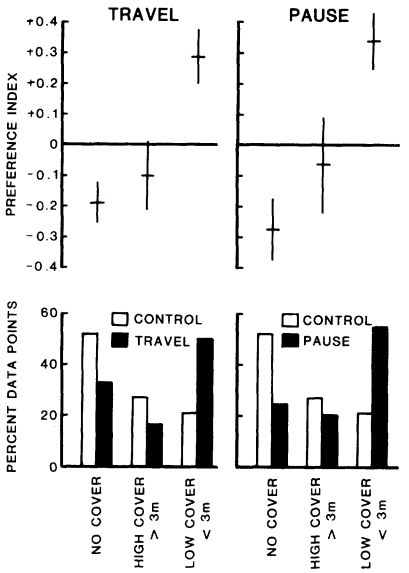

Fig. 3. Marten preference for height of overhead cover at travel and pause points. Above: preference index = relative use minus relative availability. Vertical bars represent 95% confidence intervals. Below: frequency within each class of overhead cover.

observed in 1976–77. The absence of chipmunks and ground squirrels in 1979–80 suggested that deep snow may prevent marten from capturing these prey. Ground squirrels were not found in scats collected in late winter 1977 when the snowpack exceeded 30 cm.

Fish occurred in scats only through mid-January 1977, when the Tuolumne River was free of snow and fish were trapped in small pools. The appearance of juniper berries in scats in 1979–80 was attributed to an unusually large crop that winter, and was perhaps coupled with a reduction in availability of other food sources.

Marten may avoid large open areas because of the energy expenditure of obtaining prey beneath the snow. Although marten can dig directly through the snowpack, it may be energetically more costly than using natural crevices around tree trunks, rocks, and logs protruding from the snow. When snow cover is not a factor, open areas are used. For example, Grinnell et al. (1937) reported marten using rock slides during the summer, and Soutiere (1978) observed marten use of clear-cuts when the snow depth was low, but not when snow was deep. Koehler and Hornocker (1977) found open areas used more frequently during a low-snowpack winter.

Avoiding openings and traveling under trees may minimize risk of predation (Herman and Fuller 1974, Pulliainen 1981*b*). Golden eagles (*Aquila chrysaetos*) and great horned owls (*Bubo virginianus*) are thought to be the principal predators of marten in California (Grinnell et al. 1937), and golden eagles are known predators of *M. martes* in Finland (Pulliainen 1981*b*). In the present study, dense, low-hanging branches seemed to be chosen for concealment. Simon (1980) and Spencer (1981) observed that rest stops were under or near escape cover.

MANAGEMENT IMPLICATIONS

Trees used by marten for hunting and cover include all available diameter classes. After fresh snowfalls, saplings provide subnivean access because loosely packed snow creates interstices around the buried branches. Large trees are used as avenues to the ground when the snow settles and leaves a melt zone around the trunk. As snow depth increases, branches of mature trees replace saplings in providing low cover. Thus, a forest with various size and age-classes will provide hunting sites and protective cover under different snow conditions, whereas even-aged stands may be more limited in their suitability. Moreover, the vegetative diversity of mixed-aged stands can support more prey species, which allows marten to compensate for the low availability of any one prey due to snow depth.

In Yosemite, suitable marten habitat results from National Park policy, which allows mixed-aged forests to be maintained through natural processes. In areas managed for timber, logging can result in direct habitat loss when large clearings are created. The impact of clear-cutting may be reduced by leaving clusters of trees spaced no farther than 50 m apart. Logs and slash should be left for foraging sites, winter dens, and subnivean travel routes (Campbell 1979, Simon 1980, Spencer 1981). Use of logs may have been underestimated in this study because much activity associated with logs occurred under the snow.

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